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ENDEMIC PHYTOPHAGOUS INSECTS ASSOCIATED WITH YELLOW STARTHISTLE IN NORTHERN IDAHO

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Abstract.—A survey of endemic phytophagous insects associated with yellow starthistle in northern Idaho was conducted during 1981 and 1982, prior to the introduction of biological control agents. These data were supplemented with later observations. Eight species of insects were confirmed feeding on parts of the weed, other than pollen and nectar. None of these significantly impacted yellow starthistle populations. This is contrasted with the situation in Europe where numerous species exploit the weed. The significance of these data to biological control efforts is discussed.

Key Words.—Insecta, *Centaurea solstitialis,* yellow starthistle, phytophagous insect fauna, survey

Yellow starthistle, *Centaurea solstitialis* L. (Asteraceae), is a Eurasian annual or biennial that now occupies over 3 million hectares in the western U.S. (Maddox et al. 1985, Maddox & Mayfield 1985). In northern Idaho, the weed infests approximately 100,000 ha, primarily in five counties along the Snake and Clearwater Rivers (Callihan et al. 1989). *Centaurea solstitialis* is capable of forming solid stands that eliminate grazing capacity on rangelands in this area.

In northern Idaho, *C. solstitialis* typically germinates in the fall. Rosettes with seven or eight leaves form in the spring. The plants bolt during May and June, with flowering occurring from mid-June through early August. Thus, it blooms and senesces later in the season than most plants in the area.

A survey to assess the impact of endemic insects on *C. solstitialis* was conducted prior to the release of biological control agents. The data also allow comparison with the European insect fauna of *C. solstitialis.* These comparisons may identify open niches that could be exploited by introduced biocontrol agents.

MATERIALS AND METHODS

Site Descriptions.—Three sites in the primary *C. solstitialis* infestation (100,000 ha) area of Nez Perce County in northern Idaho were selected for study. Site 1 was a 1 ha plot on a SE facing 30° slope, located 5.1 km ENE of Culdesac. This site had a loam soil and was relatively little disturbed, retaining some native vegetation. The mean elevation was 965 m. *Centaurea solstitialis* density was 187.6 plants/m^2, forming 14.5% of the ground cover. Other common species were *Poa secunda* Presl, *Ventenata dubia* (Leers) Cosson & Durieu, *Agropyron spicatum* (Pursch) Scribner & Smith (Poaceae), *Symphoricarpus albus* (L.) Blake (Caprifoliaceae), *Allium douglasii* Hooker (Liliaceae), *Balsamorhiza sagittata* (Purschall) Nuttall (Asteraceae) and *Lomatium dissectium* (Nuttall) Mathias & Constance (Apiaceae).

Site 2 was a 1 ha plot on a SE facing 40° slope, 8 km NW of Culdesac. The soil was a silt loam loess. The mean elevation was 645 m. *Centaurea solstitialis* density averaged 632.7/m^2 and formed 24.5% of the vegetative cover. The second most abundant plant species was *Dipsacus sylvestris* Hudson (Dipsacaceae) with 140.3 plants/m^2 forming 21.4% of the ground cover. Other common species were *Hypericum perforatum* L. (Clusiaceae) and *Poa pratensis* L.

Site 3 was a 4 ha plot located 8 km S of Lapwai on a 5–20° SW facing slope. The soil was a skeletal loam. The mean elevation was 650 m. *Centaurea solstitialis* density averaged 177.2/m^2 and formed 15.3% of the ground cover. Other common species included four grasses, *Poa bulbosa* L., *Festuca myuros* L., *Bromus tectorum* L. and *B. secalinus* L. (Poaceae), and two forbs *Erodium cicutarium* (L.) L'Heritier (Geraniaceae) and *Balsamorhiza sagittata.*

Sampling Methods.—Arthropods were sampled weekly from the rosette stage to senescence, May through October, 1981 and 1982, using pitfall traps, sweepnets and hand-picking. Ten pitfall traps were set at 10 m intervals along a transect that ran up the slope at each site. The traps consisted of removable 8 oz plastic cups (7.2 cm diameter) filled to a depth of 2–3 cm with ethylene glycol. These were set in permanently positioned 10 oz cups of the same diameter to minimize soil disturbance. Samples were collected by pouring the ethylene glycol through a fine-mesh (4 threads/mm) aquarium net. Items caught in the net were transferred to 70% ethyl alcohol for storage and transport to the laboratory. Fifty sweepnet samples were collected by taking 180° sweeps along a transect 10 m from, and parallel to, the line of pitfall traps. Net contents were put into a cyanide jar to kill the insects collected, then transferred to a plastic bag for transport to the laboratory. These two collecting methods yielded qualitative assessments of the abundance of arthropods in the yellow starthistle-dominated habitats. A 20–30 min period of observation and hand-picking of insects feeding on *C. solstitialis* was conducted on each sample date throughout the study and later as opportunities arose. Specimens were identified as far as taxonomically possible.

RESULTS AND DISCUSSION

The sampling yielded over 11,000 collections that included 488 recognizable arthropod taxa. Of these, 453 were insects, representing 17 orders and 131 families. Only 50 species in nine orders and 25 families were directly associated with *C. solstitialis.* Eight endemic species were observed to feed on *C. solstitialis,* other than as a source of pollen and nectar. Only two species appeared to regularly exploit *C. solstitialis.* Unless otherwise noted, the species discussed below occurred at all sites.

The species observed feeding on *C. solstitialis* included the western flower thrips *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae), meadow spittlebug, *Philaenus spuramrius* (L.) (Homoptera: Cercopidae), plum leaf curl aphid, *Brachycaudus helichrysi* (Kaltenbach) (Homoptera: Aphididae), larvae of the moth *Sparganothus tunicana* (Walshingham) (Lepidoptera: Tortricidae), an ant, *Formica* sp. (Hymenoptera: Formicidae), the migratory grasshopper, *Melanoplus sanguinipes* (Fabr.) (Orthoptera: Acrididae), a cutworm larva (Lepidoptera: Noctuidae) and the European earwig, *Forficula auricularia* L. (Dermaptera: Forficulidae).

Western flower thrips were regularly found in *C. solstitialis* flowers during visual inspections. They were also abundant in sweepnet samples taken while flowers were present. The thrips did not appear to damage *D. solstitialis.*

Meadow spittlebugs were often found on lower foliage of *C. solstitialis* throughout the spring and summer. Spittlebug densities as high as 14 per plant were observed. There was no obvious damage to *C. solstitialis* in the field attributable to spittlebug feeding.

Plum leaf curl aphids were occasionally found on the apex of elongating *C. solstitialis* stems during June. They caused the stem to curl, but were too scarce to contribute to controlling the weed. This aphid host alternates between plum trees and a wide variety of composites, including spotted knapweed, *Centaurea maculosa* Lambert (J. P. McCaffrey, unpublished data).

A population of the moth, *S. tunicana* was found feeding and developing on *C. solstitialis* at Site 1. It was first found on plants during 1985. Beginning in May of 1986, the site was visited weekly to check for the occurrence of *S. tunicana.* Larvae were not found until 30 May, at which time mid-instar larvae were found. This suggests that larvae overwinter. A related species *S. sencionana* (Walsingham) also overwinters as larvae that move to low-growing herbs (J. A. Powell, personal communication). Damage by *S. tunicana* frequently resulted in partial to complete lodging of the stem and in several instances caused the terminal portions of the plant to die back. The larvae were less common in 1987, and many were parasitized by an external parasitoid.

A single colony of *Formica* sp. at Site 2 chewed into maturing *C. solstitialis* seedheads and consumed the seeds. The impact of the ants was limited to a radius of approximately 10 m from their colony. Other colonies of apparently conspecific ants occurred at Site 2, but no other evidence of this behavior was observed.

Three other insect taxa were seen feeding on *C. solstitialis.* Late in the summer grasshoppers occasionally consumed *C. solstitialis* foliage when other vegetation in the area had senesced. A single cutworm larva was observed consuming *C. solstitialis* foliage. Rearing was attempted, but three days later it died, though it is not clear that this was due to being restricted to a diet of *C. solstitialis.* Lastly, earwigs were occasionally observed feeding in *C. solstitialis* blossoms, consuming pollen and doing minor damage to the flowers.

Pollen and nectar feeders were numerous, representing eight orders, 41 families and approximately 80 species. Most of these were Hymenoptera, especially bees (*Apis mellifera* L., *Bombus* spp. (Apidae); *Melissodes bimaculata* (Lepeletier) (Anthophoridae); and *Dialictus* spp. (Halictidae)), or Diptera (most commonly Syrphidae, e.g., *Eumerus strigatus* (Fallen) and *Sphaerophoria mehthastri* (L.)). Included in this group were a few agricultural pests (e.g., the pea leaf weevil, *Sitona lineatus* (L.) (Coleoptera: Curculionidae)). However, numerous beneficial insects also utilized this resource, including Hymenoptera such as *Dacnusa* sp. (Braconidae), *Banchus* sp. (Ichneumonidae), and numerous Chalcidoidea. *Hyalomyodes* sp. and *Eugymnogaster* sp. (Diptera: Tachinidae) were also commonly observed feeding within the flowers.

In addition to these taxa, many adult phytophagous insects were found on *C. solstitialis,* but were not observed feeding. The dominant groups in this category were Hemiptera, especially *Lygus* spp. (Miridae), *Coenus delius* (Say) and *Neotiglossus tumidifrons* Downes (Pentatomidae), and Homoptera, primarily *Dikraneura* spp. and *Deltocephalus* spp. (Cicadellidae). Despite the lack of direct observation, it is likely that some of these polyphagous species fed on *C. solstitialis* to a limited extent.

Thus, it appears that *C. solstitialis* in northern Idaho is exploited only by a few generalist ectophages and flower visitors. These insects appear to have no significant impact on *C. solstitialis* populations. This situation contrasts with reports from Europe.

The entomofauna of *C. solstitialis* in its home range has been studied by entomologists since the late 1950s (Zwölfer 1965). These studies have characterized European populations of *C. solstitialis* as primarily occurring in pastures, open fields, and ruderal situations (Sobhian & Zwölfer 1985, Clement 1990), as they do in the U.S. However, the populations of *C. solstitialis* typically encountered in southern Europe occupied <3.5 ha (Clement 1990) and were far less dense than commonly found in the U.S. (S. Clement, personal communication). Despite the reduced abundance of *C. solstitialis,* numerous insect taxa have been found associated with the weed in Europe. Clement (1990) reported 42 species of herbivores associated with *C. solstitialis* in southern Europe. Homoptera, Coleoptera, Lepidoptera, Diptera and Hymenoptera dominated in all three surveys. Many of the insect species associated with *C. solstitialis* are capitulum-feeders, but all parts of the plant are exploited (Clement 1990). Many of the species are stenophagous endophages and some appeared to be monophagous, particularly among the capitulum-feeders (Maddox & Sobhian 1987, Clement 1990, Groppe et al. 1990, Maddox et al. 1990, Clement & Sobhian 1991, Fornasari et al. in press).

Thus, it seems likely that native phytophagous insects will not interfere with introductions of biological control agents on *C. solstitialis* in northern Idaho. The resident fauna is sparse and comprised of generalists. The European fauna includes at least 18 monophagous to oligophagous taxa that might be suitable for introduction, although five capitulum-feeding species appear to have the greatest potential for use in biological control (Clement 1990). Four of these have already been released in the U.S.: *Bangasternus orientalis* (Capiomont), *Eustenopus villosus* (Boheman) (Coleoptera: Curculionidae), *Chaetorellia australis* Hering and *Urophora sirunaseva* (Hering) (Diptera: Tephritidae). As of yet, only *B. orientalis* has become widespread and well established (Turner et al. in press), so it is too early to assess their impact on *C. solstitialis* in the U.S.

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LITERATURE CITED

Callihan, R. H., F. E. Northam, J. B. Johnson, E. L. Michalson & T. S. Prather. 1989. Yellow starthistle, biology and management in pasture and rangeland. Univ. Idaho Curr. Inf. Ser. 634.

Clement, S. L. 1990. Insect natural enemies of yellow starthistle in southern Europe and the selection of candidate biological control agents. Environ. Entomol., 19: 1882–1888.

Clement, S. L. & R. Sobhian. 1991. Host-use patterns of capitulum-feeding insects of yellow starthistle: results from a garden plot in Greece. Environ. Entomol., 20: 724–730.

Fornasari, L., C. E. Turner & L. A. Andres. (in press). *Eustenopus villosus* (Coleoptera: Curculionidae) for biological control of yellow starthistle (Asteraceae: Cardueae) in North America. Environ. Entomol.

Groppe, K., R. Sobhian & J. Kashefi. 1990. A field experiment to determine host specificity of *Larinus curtus* Hochhut (Col., Curculionidae) and *Urophora sirunaseva* Hg. (Dipt., Tephritidae), candidates for the biological control of *Centaurea solstitialis* L. (Asteraceae), and *Larinus minutus* Gyllenhal, a candidate for biological control of *C. maculosa* Lam. and *C. diffusa* Lam. J. Appl. Ent., 110: 300–306.

Maddox, D. M. & A. Mayfield. 1985. Yellow starthistle infestations are on the increase. Calif. Agric., 39(11–12): 10–12.

Maddox, D. M., A. Mayfield & N. H. Poritz. 1985. Distribution of yellow starthistle (*Centaurea solstitialis*) and Russian knapweed (*Centaurea repens*). Weed Sci., 33: 315–327.

Maddox, D. M., A. Mayfield & C. E. Turner. 1990. Host specificity of *Chaetorellia australis* (Diptera: Tephritidae) for biological control of yellow starthistle (*Centaurea solstitialis,* Asteraceae). Proc. Entomol. Soc. Wash., 92: 426–430.

Maddox, D. M. & R. Sobhian. 1987. Field experiment to determine host specificity and oviposition behavior of *Bangasternus orientalis* and *Bangasternus fausti* (Coleoptera: Curculionidae), biological control agents for yellow starthistle and diffuse knapweed. Environ. Entomol., 16: 645–648.

Sobhian, R. & H. Zwölfer. 1985. Phytophagous insect species associated with flower heads of yellow starthistle (*Centaurea solstitialis* L.). Z. Agnew. Entomol., 99: 301–321.

Turner, C. E., J. B. Johnson & J. P. McCaffrey. (in press). Yellow starthistle, *Centaurea solstitialis* L. (Asterales: Asteraceae). *In* Nechols, J. R., L. A. Andres, J. W. Beardsley, R. D. Goeden & C. G. Jackson (eds.). Biological control in the U.S. western region: accomplishments and benefits of regional research project W-84 (1964–1989). University of California Press, Riverside.

Zwölfer, H. 1965. Preliminary list of phytophagous insects attacking wild Cynareae (Compositae) in Europe. Commonw. Inst. Biol. Control Tech. Bull., 6: 81–154.

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